The Scintillation Prediction Observations Research Task (SPORT): A Pathfinder Mission

James F. Spann (NASA/MSFC), Charles Swenson (USU), Otavio Durão (INPE), Luis Loures (ITA), Rod Heelis (UTD), Rebecca Bishop (Aerospace), Guan Le (NASA/GSFC), Mangalathayuil Abdu (ITA), Linda Krause (NASA/MSFC),
Clezio Dinardini (INPE), Joaquim da Costa (INPE), Polinaya Muraliskrishna (INPE) — Contact email: jim.spann@nasa.gov

Science

The Scintillation Prediction Observations Research Task (SPORT) mission tackles the very difficult problem of understanding the conditions under which ionospheric variability develops that leads to scintillation that compromises transmission signals. SPORT seeks to answer:

- **What is the state of the ionosphere that gives rise to the growth of plasma irregularities that extend into and above the F-peak giving rise to scintillation?**
- **How do plasma irregularities impact the appearnce of radio scintillation at differenct frequencies?**

SPORT is science mission using a 6U CubeSat and integrated ground network that will (1) advance understanding and (2) enable improved predictions of scintillation occurrence that impact GPS signals and radio communications. This is the science of Space Weather. SPORT is an international partnership with NASA, U.S. institutions, the Brazilian National Institute for Space Research (INPE), and the Technical Aeronautics Institute under the Brazilian Air Force Command Department (DCTA/ITA).

Science Traceability Matrix

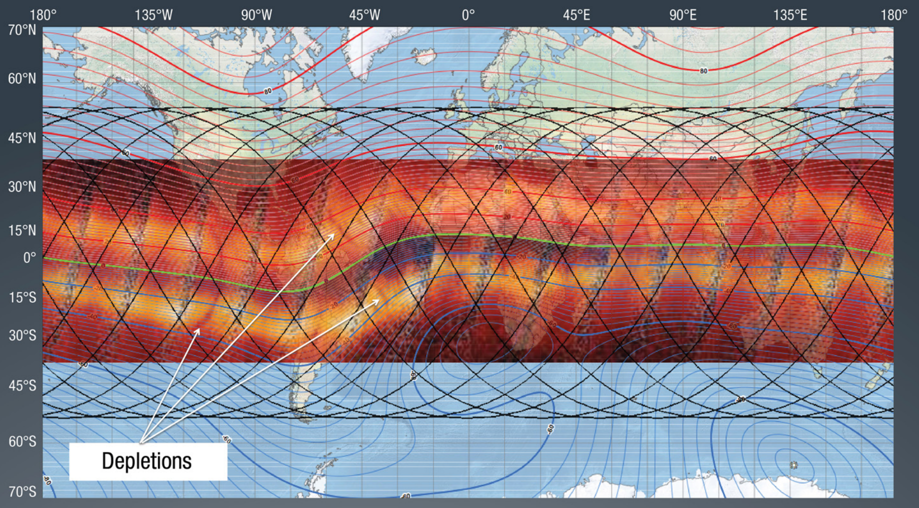
The Scintillation Prediction Observations Research Task (SPORT)		Instrumentation	Spacecraft
Observational Approach	**Science Measurement Requirements**	**Instrument Approach**	**Space Systems Requirements**
1. What is the state of the ionosphere that gives rise to the growth of plasma irregularities that extend into and above the F-peak?			
Observations in the 17:00 to 1:00 LY sector over –30° to 30° latitude Height profiles of the plasma density to specify the magnitude and height of the F peak density in the EA Vertical ion drifts at or beow the F peak in the EA	**Plasma Density Profile** 1. 140 to 450 km alt 2. 10^4 to 10^7 p/cm^3 range 3. 20% p/cm^3 accuracy 4. 1000 km along track sampling **Ion Drifts (EarthReference Frame)** 1. ±800 m/s Range 2. 20 m/s precision & accuracy 3. 10 km along track sampling	**GPS Occulation** Observe GPS satellite occultation along and to the sides of the orbit plane to obtain line of site TEC **Ion Velocity Meter** Observe vertical ion drifts by angle of arrival of heavy ions at detector	**Satellite Orbit** 1. ≥1 year mission life 2. 40° to 55° inclination 3. 350 to 450 km altitude 4. ±10 km eccentricity **Spacecraft** 1. ±15° yer mission life 2. ≤1 km position knowldge 3. ≤10 ms timeing
2. How do plasma irregularities evolve to impact the appearance of radio scintillation at different frequencies?			
Observations in the 22:00 to 2:00 LT sector over over –30° to 30° latitude Observations of irregularities in electron density and E-field power spectral density in slope from 200 km to 200 m	**E-Field (Earth Reference Frame)** 1. ±45 mV/m range 2. 1.1 mV/m precision & accuracy 3. 1 km along track sampling 4. 10 km – 200 m along track waves **Plasma Density** 1. 10^3 to 107 p/cm^3 range 2. 10^3 p/cm^3 precision & accuracy 3. 1 km along track sampling 4. 10 km – 200 m along track waves **B-field** 1. ± 56,000 nT range 2. ±100 nT precision and accuracy 3. 1 km along track sampling	**E-Field Double Probe** Observe probe floating potential for AC E-fields from irregularity **GPS Occultation** S4 scintillation index **Langmuir/Impedance** Observe DC and AC probe response for relative and absolute electron density and observe irregularities **Three Axis Magnetometer** Support VxB computation for ion velocity and E-Field measurements	**Spacecraft Mechanisms** 1. ≥0.6 m tip-to-tip booms **Attitude (Post Flight Knowledge)** 1. ≤0.02° 1σ-uncertainty

Instruments

Expected Instrument Performance and Requirements

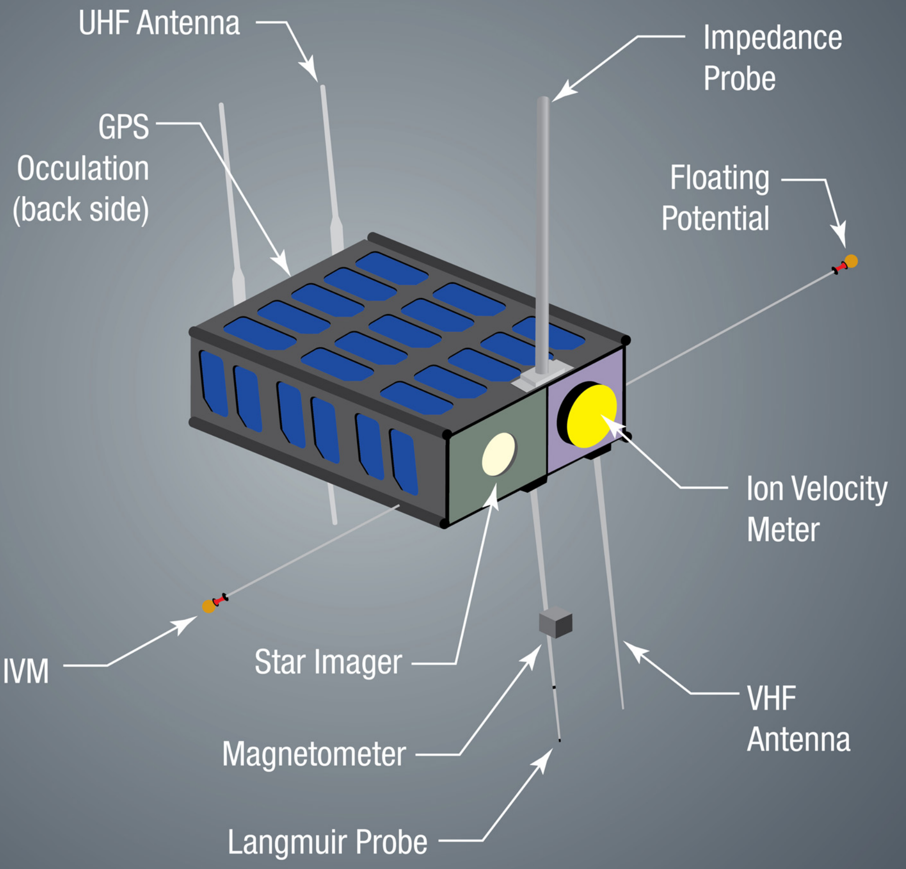
Parameter	Ion Velocity Meter	GPS Occultation	Electric Field Probe	Langmuir Probe	Impedance Probe	Magnetometer
Scientific Requirement	V_i: ±800 m/s, 20 m/s ΔNi: 10^4 to 10^7 cm^{-3}	N_e-Profile: 10^4 to 10^7 cm^{-3} S4 0.2 to 1.2	0.1 to ±45 mV/m	ΔN_e: 10^3 to 10^7 cm^{-3} ΔN_i: 10^3 to 10^7 cm^{-3}	N_e: 10^3 to 10^7 cm^{-3}	± 56,000 nT, 100 nT
Instrument Performance	V_i: ±1000 m/s, 15 m/s ΔN_i: 10^2 to 10^7 cm^{-3}, 5% T_i: 250 to 5000 K C_i : 0–100%, 1–40 amu DC to 2 Hz	Scintillations (S4) Slant TEC: 3 to 200 units Ne-Profile: 10^3 to 10^7 cm^{-3} S4 0.1 to 1.5 σ: 0.1 to 20 rads 50 Hz	0.1 to 500 mV/m, 1% V_i (derived): 20 m/s DC-40 Hz 16 spectrometer ch. 20 Hz to 15 kHz	ΔN_e: 10 to 10^7 cm^{-3}, 5% ΔN_i: 10^3 to 10^9 cm^{-3}, 5% T_e: 200 to 5000 K V_f : ±10 mV to ± 12 V V_p: ±10 mV to ± 12 V DC-40 Hz, 25 s/sweep 16 spectrometer ch. 20 Hz to 15 kHz	N_e: 10 to 10^7 cm^{-3}, 1% DC-40 Hz, 25 s/sweep	± 64,000 nT, 10 nT DC-40 Hz
Mechanism Attitude Control Attitude knowledge post processed req.	8 cm aperture 15° pointing control 0.02°	7.6 x 7.6 x 0.5 cm patch antenna 15° pointing control 2°	Two 30 cm booms 15° pointing control 0.02°	0.3 x 30 cm boom 15° pointing control 10°	30 cm boom 15° pointing control 10°	25 cm boom NA 2° pointing
Field of View	30°	160°	180°	180°	180°	180°
Peak Power	0.3 W	1.5 W	0.15 W	0.15 W	0.4 W	0.45 W
Volume	1.0U Cube 9 × 9 × 10 cm	~0.15U Cube 1.5 × 9 × 9 cm	~0.1U Cube (Shared with LP) 0.75 × 9 × 9 cm	~0.1U Cube (Shared with E-Field) 0.75 × 9 × 9 cm	~0.1U Cube 0.75 × 9 × 9 cm	~0.5U Cube 5 × 9 × 9 cm
Mass	< 1000 g	< 200 g	< 80 g (shared)	< 80g (shared)	< 160 g	< 150 g
Data Rate	2.0 kbps	1.0 kbps Day; 15 kbps Night	1.4 kbps	2.0 kbps	1 kbps	2.8 kbps
Horizontal Cell Size	100 km	500 km	200 m; 20 m spectrometer	200 m; 20 m spectrometer	190 km	10 km
Vertical Cell Size	NA	30 km	NA	NA	NA	NA

V_i – ion drift velocities; ΔN_i – relative ion density; ΔN_e – relative electron density; T_e – electron temperature; T_i – ion temperature ; V_f – floating potential ; V_p – plasma potential ; N_e- electron density; B – Magnetic Field ; TEC – total electron content; C_i – Ion composition; DC – 1D DC Electric Field; S4 – RF signal amplitude index, σ – RF signal phase index

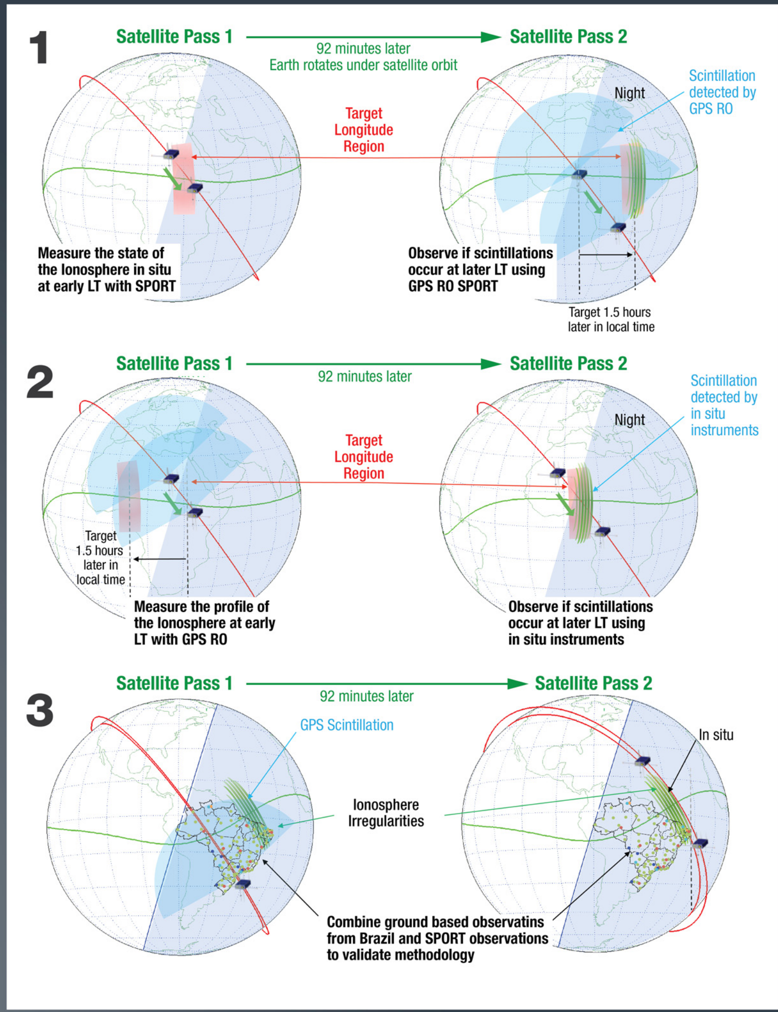


UV Airglow images from TIMED GUVI clearly showing the equatorial anomaly with embedded depletions that have penetrated through the F peak. Green, Red and Blue traces show the magnetic equator and positive and negative dip angles. SPORT 52° inclination ground tracks are superimposed as black traces.

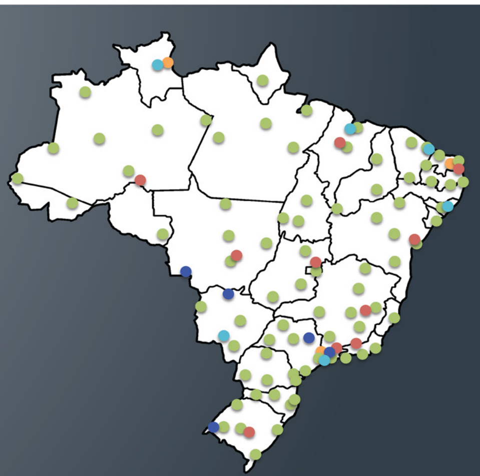
SPORT Spacecraft



Strategy



Ground Network



- Magnetometers
- Scintillation Sensors
- TEC Stations
- Imagers
- Ionosondes

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